Final Report
F-B2303-5

Technical Report

SENSITIVITY OF THE HI-SHEAR VERSION OF THE APOLLO STANDARD INITIATOR TO 9000 MEGAHERTZ PULSED ENERGY

(Task No. 5)

by

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August 1966

Prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Manned Spacecraft Center
Houston, Texas

Contract No. NAS9-3787-5

THE FRANKLIN INSTITUTE RESEARCH LABORATORIES

BENJAMIN FRANKLIN PARKWAY AT 20TH STREET, PHILA. 3, PA.

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Contract No. NAS9-3878-5
12 Pages Including Data Sheets

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ABSTRACT

Twelve (Hi-Shear) Apollo Standard Initiators were tested at 9000 MHz, pulsed, in the bridgewire mode, pins-to-case mode and bridgewire-to-bridgewire mode. There does not appear to be any significant difference between this device and those tested previously (SO1-266-6).

Non-destructive tests (parameter measurements) did not reveal any change in the devices when exposed to 9000 MHz before firing.

ACKNOWLEDGEMENTS

This report was prepared by the Applied Physics Laboratory, E. E. Hannum, Manager. Major contributors were Paul F. Mohrbach, Principal Scientist, Robert F. Wood, Senior Research Engineer and George C. Roatche, Technical Associate.

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1. INTRODUCTION

The purpose of this task is to determine the susceptibility of the Hi-Shear version of the Apollo Standard Initiator to 9000 megahertz pulsed energy when applied in the following three modes:

1. Pin-to-pin
2. Pins-to-case
3. Bridgewire-to-bridgewire

We have taken the results from these tests and compared them with results from tests conducted on the Apollo Standard Initiator (Space Ordnance Systems Number SO1-266-6) during May, 1965.

2. 9000 MHz TESTS

In RF sensitivity tests performed on the standard ASI (SO1-266-6) in a previous study, (Final Report F-B2303-1, "Radio Frequency Evaluation of Apollo Standard Initiator", May, 1965) the ASI was found to be quite sensitive at 9000 MHz, pulsed, and was approximately equally sensitive regardless of whether the RF power was applied pin-to-pin, pins-to-case or bridgewire-to-bridgewire. It was inferred from this that initiation might be occurring in the same manner regardless of where the power was applied; for example, the device might always initiate between the pins and the case.

The purpose of this present task is to determine if the Hi-Shear version of the ASI differs radically from the Space Ordnance Systems ASI. A comparison of the results of the 9000 MHz tests are shown in Tables 2-1, 2-2 and 2-3. We have included the data on the original ASI for comparison purposes. A summary of these data is tabulated in Table 2-4.

It would appear that the Hi-Shear device is slightly more sensitive that the S.O.S. ASI in the bridgewire mode and the pins-to-case mode. In view of the limited number of devices tested, however, the best that can be said is that the Hi-Shear device is not radically different from the S.O.S. ASI that we tested.

Table 2-1
BRIDGEWIRE TESTS

a) Hi-Shear ASI

Test No.	Test Freq (MHz)	Power Mode	Power to EED (watts)	No. Non-Fires	No. Fires
RF-1443	9000	Pulsed 1.5 Micro-second 1000 PPS	0.10	3	1
			0.20	0	3

Conclusions: Average power mean about 0.15 watts. Peak power mean about 100 watts.

b) S.O.S. (SOI-266-6) ASI

Test No.	Test Freq (MHz)	Power Mode	Power to EED (watts)	No. Non-Fires	No. Fires
RF-1135	9000	Pulsed 1.5 Micro-second 1000 PPS	0.30	2	0
			0.40	3	1
			0.45	0	2
			0.50	0	2

Conclusions: Average power mean about 0.4 watts. Peak power mean about 267 watts.

RF-1136 Bruceton Test	9000	Pulsed 1.5 Micro-second 1000 PPS	No. tested = 40 Sigma = 0.11340 99.9%(*) = 1.49 Watts 50% = 0.37 Watts 0.1(*) = 0.092 Watts peak power 99.9%(*) = 994 Watts peak power 50% = 247 Watts peak power 0.1% = 61 Watts

*95% Confidence

Table 2-2
PINS-TO-CASE TESTS

a) Hi-Shear ASI

Test No.	Test Freq (MH_z)	Power Mode	Power to EED (watts)	No. Non-Fires	No. Fires
RF- 1444	9000	Pulsed 1.5 Micro-second 1000 PPS	0.10	4	0
			0.20	3	1
			0.30	1	2
			0.40	0	1

Conclusions: Average power mean about 0.25 watts. Peak power mean about 167 watts.

b) S.O.S. (S01-266-6) ASI

Test No.	Test Freq (MH_z)	Power Mode	Power to EED (watts)	No. Non-Fires	No. Fires
RF-1141	9000	Pulsed 1.5 Micro-second 1000 PPS	0.20	2	0
			0.30	2	0
			0.35	2	0
			0.40	2	4

Conclusions: Average power mean about 0.4 watts. Peak power mean about 267 watts.

Table 2-3

BRIDGEWIRE-TO-BRIDGEWIRE TESTS

a) Hi-Shear ASI

Test No.	Test Freq (MH_z)	Power Mode	Power to EED (watts)	No. Non-Fires	No. Fires
RF-1445	9000	Pulsed 1.5 Micro-second 1000 PPS	0.10	3	1
			0.20	2	1
			0.30	0	2

Conclusions: Average power mean about 0.25 watts. Peak power mean about 167 watts.

b) S.O.S. (SOI-266-6) ASI

Test No.	Test Freq (MH_z)	Power Mode	Power to EED (watts)	No. Non-Fires	No. Fires
RF-1147	9000	Pulsed 1.5 Micro-second 1000 PPS	0.15	2	0
			0.20	1	0
			0.25	2	3
			0.35	0	1
			0.5	0	2

Conclusions: Average power mean about 0.25 watts. Peak power mean about 167 watts.

RF-1148 Bruceton Test	9000	Pulsed 1.5 Micro-second 1000 PPS	No. tested = 40 Sigma = 0.08482 99.9%(*) = 0.65 Watts 50% = 0.24 Watts 0.1%(*) = 0.089 Watts Peak power means 99.9(*) = 433 watts 50 = 160 watts 0.1(*) = ~~133~~ 59 watts

*95% Confidence

Table 2-4
ESTIMATED MEAN FIRING LEVEL (WATTS)

Mode	Hi-Shear	SO1-266-6
Bridgewire	0.15	0.40-0.37
Pin-to-Case	0.25	0.40
Bridgewire-to-Bridgewire	0.25	0.24

3. PARAMETER MEASUREMENTS ON THE HI-SHEAR INITIATOR BEFORE AND AFTER RADIO FREQUENCY EXPOSURE

As requested in Exhibit "A" (Statement of Work) of contract No. NAS 9-3787-5 several parameters of the Hi-Shear Apollo Standard Initiator were measured before and after exposure to radio frequency power. These measurements were made to determine the effect of radio frequency exposure on these parameters. After a visual inspection, the quantities determined were: bridgewire resistance, insulation resistance, inter-bridge capacitance, pin-to-case capacitance and bridgewire-to-bridgewire resistance. Results of these observations are tabulated in Tables 3-1 to 3-3. From these data we would conclude that these parameters are not affected by the application of the RF energy.

Table 3-1

PRE-FIRING DATA SHEET (BRIDGEWIRE MODE)

TEST GROUP: Hi-Shear

DATE: 7-29-66

	INITIATOR SERIAL NO.	VISUAL INSPECTION		BRIDGEWIRE RESISTANCE (OHMS) A-B		BRIDGEWIRE RESISTANCE (OHMS) C-D		INSULATION RESISTANCE (OHMS)		INNER BRIDGE CAPACITANCE (μμF)		PINS TO CASE CAPACITANCE (μμF)		BRIDGE TO BRIDGE RESISTANCE (OHMS)		REMARKS
		BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	
100 MW.	18	OK	✓	1.13	1.10	1.15	1.11	4×10^{11}	2×10^{11}	6.7	5.1	6.5	6.4	$\gg 2.8\times10^{10}$	$\gg 2.8\times10^{10}$	
	25	OK	—	1.07	—	1.10	—	7×10^{11}	—	5.0	—	6.7	—	$\gg 2.8\times10^{10}$	—	FIRED
	55	OK	✓	1.12	1.09	1.11	1.06	7×10^{11}	2×10^{11}	6.7	5.1	6.0	6.3	$\gg 2.8\times10^{10}$	$\gg 2.8\times10^{10}$	
	64	OK	✓	1.10	1.09	1.13	1.05	9×10^{11}	2×10^{11}	5.5	5.0	6.0	6.5	$\gg 2.8\times10^{10}$	$\gg 2.8\times10^{10}$	
200 MW	18	OK		1.10	—	1.11	—	2×10^{11}	—	5.1	—	6.4	—	$\gg 2.8\times10^{10}$	—	FIRED
	55	OK		1.09	—	1.06	—	2×10^{11}	—	5.1	—	6.3	—	$\gg 2.8\times10^{10}$	—	FIRED
	64	OK		1.09	—	1.05	—	2×10^{11}	—	5.0	—	6.5	—	$\gg 2.8\times10^{10}$		FIRED

Table 3-2

PRE-FIRING DATA SHEET (PINS-TO-CASE MODE)

TEST GROUP: Hi-Shear

DATE: 7-28-66

	INITIATOR SERIAL NO.	VISUAL INSPECTION		BRIDGEWIRE RESISTANCE (OHMS) A-B		BRIDGEWIRE RESISTANCE (OHMS) C-D		INSULATION RESISTANCE (OHMS) BEFORE	INSULATION RESISTANCE (OHMS) AFTER	INNER BRIDGE CAPACITANCE (μμF) BEFORE	INNER BRIDGE CAPACITANCE (μμF) AFTER	PINS TO CASE CAPACITANCE (μμF) BEFORE	PINS TO CASE CAPACITANCE (μμF) AFTER	BRIDGE TO BRIDGE RESISTANCE (OHMS) BEFORE	BRIDGE TO BRIDGE RESISTANCE (OHMS) AFTER	REMARKS
		BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER									
100 MW	20	OK	✓	1.13	1.10	1.12	1.10	5×10^{11}	2×10^{11}	6.5	4.7	6.5	6.8	$\gg 2.8\times10^{10}$	$\gg 2.8\times10^{10}$	
	21	ok	✓	1.13	1.10	1.10	1.08	7×10^{11}	3×10^{11}	5.5	5.2	7.5	6.7	$\gg 2.8\times10^{10}$	$\gg 2.8\times10^{10}$	
	36	ok	✓	1.16	1.16	1.15	1.14	6×10^{11}	4×10^{11}	6.0	4.7	6.7	6.9	$\gg 2.8\times10^{10}$	$\gg 2.8\times10^{10}$	
	52	ok	✓	1.11	1.09	1.14	1.10	7×10^{11}	3×10^{11}	6.7	4.6	7.5	6.5	$\gg 2.8\times10^{10}$	$\gg 2.8\times10^{10}$	

Table 3-2

PRE-FIRING DATA SHEET (PINS-TO-CASE MODE)

TEST GROUP: Hi-Shear

DATE: 7-28-66

	INITIATOR SERIAL NO.	VISUAL INSPECTION		BRIDGEWIRE RESISTANCE (OHMS) A-B		BRIDGEWIRE RESISTANCE (OHMS) C-D		INSULATION RESISTANCE (OHMS)		INNER BRIDGE CAPACITANCE (μμF)		PINS TO CASE CAPACITANCE (μμF)		BRIDGE TO BRIDGE RESISTANCE (OHMS)		REMARKS
		BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	
200 MW	20	OK	✓	1.10	1.10	1.10	1.08	2×10^{11}	2×10^{11}	4.7	4.3	6.8	6.4	$\gg 2.8 \times 10^{10}$	$\gg 2.8 \times 10^{10}$	
	21	OK	—	1.10	—	1.08	—	3×10^{11}	—	5.2	—	6.7	—	$\gg 2.8 \times 10^{10}$	—	FIRED
	36	OK	✓	1.16	1.05	1.14	1.11	4×10^{11}	2×10^{11}	4.7	4.2	6.9	6.7	$\gg 2.8 \times 10^{10}$	$\gg 2.8 \times 10^{10}$	
	52	OK	✓	1.09	1.07	1.10	1.10	3×10^{11}	2×10^{11}	7.6	4.3	6.5	6.4	$\gg 2.8 \times 10^{10}$	$\gg 2.8 \times 10^{10}$	
300 MW	20	OK	✓	1.10	1.10	1.08	1.08	2×10^{11}	3×10^{11}	4.3	6.0	6.4	5.8	$\gg 2.8 \times 10^{10}$	$\gg 2.8 \times 10^{10}$	
	36	OK	—	1.05	—	1.11	—	2×10^{11}	—	4.2	—	6.7	—	$\gg 2.8 \times 10^{10}$	—	FIRED
	52	OK	-	1.05	—	1.10	—	2×10^{11}	--	4.3	—	6.4	-	$\gg 2.8 \times 10^{10}$	--	FIRED
400	20	OK		1.10	—	1.08	—	3×10^{11}	—	6.0	—	5.8	—	$\gg 2.8 \times 10^{10}$	—	FIRED

Table 3-3

PRE-FIRING DATA SHEET (BRIDGEWIRE-TO-BRIDGEWIRE MODE)

TEST GROUP: Hi-Shear

DATE: 8-1-66

	INITIATOR SERIAL NO.	VISUAL INSPECTION		BRIDGEWIRE RESISTANCE (OHMS) A-B		BRIDGEWIRE RESISTANCE (OHMS) C-D		INSULATION RESISTANCE (OHMS)		INNER BRIDGE CAPACITANCE (μμF)		PINS TO CASE CAPACITANCE (μμF)		BRIDGE TO BRIDGE RESISTANCE (OHMS)		REMARKS
		BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	
100 MW	6	OK	—	1.10	—	1.10	—	3×10^{11}	—	6.5	—	6.5	—	$>>2.8\times10^{10}$	—	FIRED
	38	OK	✓	1.10	1.09	1.12	1.09	7×10^{11}	5×10^{11}	7.0	5.8	7.0	58	$>>2.8\times10^{10}$	$>>2.8$	
	48	ok	✓	1.12	1.10	1.15	1.10	7×10^{11}	5×10^{11}	5.0	6.0	7.0	6.0	3.8×10^{8}	$>>2.8\times10^{10}$	
	68	OK	✓	1.13	**1.10**	1.14	1.10	6×10^{11}	5×10^{11}	9.0	7.5	6.0	5.7	$>>2.8\times10^{10}$	$>>2.8\times10^{10}$	
200 MW	38	Ok	—	1.05	—	**1.09**	—	5×10^{11}	—	5.8	—	5.8	—	$>>2.8\times10^{10}$	—	FIRED
	48	ok	✓	1.10	1.09	**1.10**	1.09	5×10^{11}	5×10^{11}	6.0	4.5	6.0	6.3	$>>2.8\times10^{10}$	$>>2.8\times10^{10}$	
	68	ok	✓	**1.10**	1.09	**1.10**	**1.09**	5×10^{11}	2×10^{8} UNSTABLE	7.5	5.4	5.7	6.2	$>>2.8\times10^{10}$	$>>2.8\times10^{10}$	
300 MW	48	Ok	—	**1.08**	—	**1.09**	—	5×10^{11}	—	4.5	—	6.3	—	$>>2.8\times10^{10}$	—	FIRED
	68	ok	—	1.08	—	1.09	—	2×10^{8} UNSTABLE	—	5.4	—	6.2	—	$>>2.8\times10^{10}$	—	FIRED

4. GENERAL CONCLUSIONS

An examination of the firing data given in Table 2-4 would seem to indicate than the Hi-Shear Apollo Standard Initiator is slightly more sensitive that the S.O.S. SO1-266-6 in the bridgewire mode and in the pins-to-case mode. We do not feel, however, that enough items were evaluated to substantiate this conclusion. The best we can do from these limited data is to say that the two groups of devices (Hi-Shear and SO1-266-6) are not radically different.

The effect of the 9000 MHz stimulus on the parameters of the initiators was negligible. As in the case of those devices tested during Task 4 (Report F-B2303-4) no relationship between the firing level and the parameters could be noted.

The parameters of the Hi-Shear device measured about the same as those of the SO1-266-6. If there was any difference to be noted it would be that the Hi-Shear devices had a more consistent pins-to-case resistance than previously measured ASI's.